CURRENT PROPOSALS FOR THE DETERMINATION OF THE CONSEQUENCES OF THE ACCIDENTAL INITIATION OF STACKS OF HAZARD DIVISION 1.2 AMMUNITION IN STRUCTURES

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ABSTRACT

To date nearly all International effort in the field of accidental explosion consequence determination has been aimed at the quantification of the effects of a Hazard Division 1.1 event in an explosives storage facility. Until the commencement of the programme of work described here, little attention had been payed to the consequences of the ignition of stacks of Hazard Division 1.2 ammunition either in or out of storehouses.

In 1989 NATO AC258 agreed that a programme of trials should be carried out to investigate the consequences of a HD 1.2 event with the aim of revising the current NATO quantity distance relationships and placing them on a firmer footing. The programme of trials to investigate the effects of the initiation of 105mm TNT loaded ammunition stacked in the open was commenced in 1991. A report on the results obtained at the time was given at the 25th Seminar and interim conclusions were drawn.

The programme of trials on the TNT loaded ammunition has now been completed and further analysis of the results carried out. The conclusions from the analysis are reported.

At the same time the need was identified to extend the database of effects to examine the consequences of changes in packaging, calibre and type of ammunition and the explosive fill. The resulting programme of trials is described and initial results for the first of these (examining the effects of changing from TNT to Composition B filling in 105mm ammunition) are reported.

Some progress on a programme of trials to investigate the effects of the initiation of HD 1.2 explosives in structures has been made since the 25th Seminar. Trials are now being planned to study such events in igloos. A description of the proposed Joint Australian/UK/US trials is given.

INTRODUCTION

Whilst over the last 20 years considerable international effort has been devoted to the understanding of the consequences of Hazard Division (HD) 1.1 mass explosions, very little has been done to quantify those of HD 1.2 events. HD 1.2 ammunition, when subjected to an appropriate accident stimulus (eg fire), explodes spasmodically as individual rounds become sufficiently stimulated. The probability of propagation of explosion from one round to another is minimised either by the design of the ammuntion itself, the design of the packaging or simply by the orientation of rounds within the packaging. Thus a HD 1.2 event is typically a series of single round explosions of varying frequency distributed over a prolonged period. The increasing use of risk assessment modelling in the design and safety audit of explosives facilities, coupled with a need to thoroughly validate existing Quantity-Distance (QD) formulae has lead to the development of an international program of work to understand and quantify the consequences of HD 1.2 events.

BACKGROUND

1 In 1989 NATO AC258 (Group of Experts on the Safety Aspects of Transportation and Storage of Military Ammunition and Explosives), acknowledging the frailty of the basis for their HD 1.2 QDs, agreed that a program of trials should be carried out to investigate the consequences of an accidental HD 1.2 event with the aim of revising the current NATO quantity distance relationships and placing them on a firmer footing. Exposed stack trials and trials within typical storehouse structures were proposed. It was intended that this program would also offer the opportunity for the development of a common acceptable approach to the calculation of HD 1.2 quantity-distances.

2 The US Department of Defence Explosives Safety Board (DDESB) and UK Explosives Storage and Transport Committee have, since then, sponsored a program of trials to quantify the effects from stacks of 105 mm HE ammunition exposed to a fire environment. Early results from this program were reported at the 25th DoD Seminar (Reference 1) and updated in a paper presented at PARARI 93 in Canberra, Australia (Reference 2). The results of the completed program are reported at this Seminar (Reference 3). A further US/UK program of bonfire tests on HD 1.2 ammunition is now under way to extend the base of consequence information to smaller calibre ammunition (81 mm HE mortar), alternative explosive (Composition B rather than TNT) and metal packaging as opposed to wooden boxes.

3 A proposed program of tests to investigate the effects of structures on a HD 1.2 event and its consequences was drafted (Reference 4). However, the high estimated cost of HD 1.2 tests in structures, coupled with limited US/UK funds, the lack of other international funding and concerns over the ordnance disposal implications of such tests, has delayed the implementation of this program. It was recognised that,due to the cost of performing such tests, multinational cooperation would be required.

4 In 1990, three Australian designed SPANTECH (igloo) explosives storehouses (ESH) were constructed in the desert near Woomera South Australia, to be used as receptor structures for the joint Australia/UK Phase 4 Stack Fragmentation Trials (References 5,6). The ESH were constructed with a 13 m diameter steel arch. Another ESH with a 23 m diameter steel arch was constructed later for Australian trials. The 13 m ESH survived the trials although one was superficially damaged. For the Australian SPANTECH qualification trials, two of the 13 m ESH and the new 23 m ESH were then used as acceptor structures, with the remaining 13 m ESH being used as a 75 tonne TNT NEQ donor. All acceptor structures survived the trial. As a result, and after examining the fragmentation distribution from the donor structure, the Australian Ordnance Council (AOC) qualified the tested SPANTECH designs as meeting the NATO 7 Bar design criteria (References 7,8).

5 To determine whether the surviving SPANTECH ESH were suitable for HD 1.2 explosives initiation trials, representatives of the UK ESTC, the AOC, the US DDESB and the Australian DoD Directorate of Trials (DTRIALS) visited the Woomera site in November 1993. It was agreed in principle that the HD 1.2 initiation trials could be conducted in the two surviving 13 m SPANTECH ESH but the damaged ESH would need to be repaired.

6.	There is a Memorandum of Understanding between the Government of Great Britain and Northern Ireland and the Government of the Commonwealth of Australia concerning Cooperative Defence Research, (the AMMOUR), and it was due to this MoU that the earlier joint large scale ESH stack fragmentation trials were conducted. The Australian DoD and UK MoD are now negotiating conducting the HD 1.2 trials in 1995 under the aegis of this MoU. The US have offered assistance with the provision of suitable ammunition types and with instrumentation.

EXISTING TEST INFORMATION

7	Whilst there is some information on the consequences of events involving exposed stacks of HD 1.2 ammunition, for example the current UK/US trials programs mentioned above and tests on 40 mm L/60 ammunition carried out by Norway as the result of a transport accident in 1985 (References 9,10), there is little reported on the consequences of such events within structures.

8	Some work was carried out in 1986 by Nakahara et al (Reference 11) to determine the effects of bonfire cook-off on TNT filled 105 mm HE shell in a model underground magazine. 24 rounds in 12 wooden boxes were subjected to the bonfire test in a 1.8 m x 1.8 m x 12 m reinforced concrete magazine covered to a depth of 3 m in an earth embankment. One end was left open. They observed that the reaction of the ammunition was similar to that seen in the recent exposed stack trials. Propellant started to react after 23 minutes, the first explosion occurred after 33 minutes and the last explosion was 1 hour 45 minutes after the fire was lit. Of the 24 rounds tested 10 reacted. There was no evidence of the full detonation of any round.Damage to the structure was limited to local scabbing down to the reinforcing and some heat cracking. Most fragmentation and debris was contained within the magazine or within 10m of the open end. The maximum throw distances were 50 m for a projectile fragment and 90 m for a cartridge case. They reference work by Kuroda (Reference 12) in which quantities of blank and live ammunition of 20 mm calibre and below were tested in similar circumstances. As might be expected there was minimal damage to the magazine and he comments that any external fragmentation can be stopped by a simple concrete barrier in front of the magazine entrance.

9	In 1978 a trial, sponsored by the UK ESTC, was carried out to determine the effects of the progressive detonation of a series of small charges (Reference 13), ie simulating a HD 1.2 event, in an ammunition store. The structure used had one 400 mm cavity wall, one 340 mm solid wall and two 225 mm solid walls, all of brick construction.The charges used were Bombs 2" Mortar with a total charge weight of 0.2 kg. They were placed against the outer, cavity, wall of the building. After each detonation the structure was examined and damage recorded. The wall was ruptured after 13 detonations. It was concluded that a building of cavity brick wall construction would contain fragments from such explosions for a sufficient time to allow evacuation of personnel from nearby buildings. Fragments would only become a potential hazard once the building had collapsed. Later experiments using 81 mm HE mortar showed that it was possible to collapse this type of building with one detonation.

10	Crockart and Bone of the Weapons Systems Support Laboratory, Salisbury, S. Australia (Reference 14) did similar experiments using a single 105 mm HE shell and

small bare charges. The structure was again a cavity brick wall, concrete roof building. They showed that, at a stand-off of approximately 1.5 m, the detonation of a 105 mm shell (2.5 kg NEQ) caused local disruption of the wall. There was, however, no evidence on witness screens of primary or secondary fragmentation being projected far beyond the wall rupture. From this experiment and those conducted with bare charges they concluded that, for HD 1.2 situations up to 2.5 kg NEQ, effective primary fragment containment can be expected from double brick walls, provided that

a. charges are located at, or further than $0.8Q^{1/3}$ m from the wall where Q is the net TNT eqivalent explosive quantity in kg.

b. the wall is of sufficient height to intercept all low angle fragments

c. adequate precautions are taken to ensure that door and window openings are screened.

THE NEED FOR FURTHER INFORMATION

11 While some of the trials described above have attempted to examine the effect of multiple explosions on containing structures, the numbers of explosions studied have been very small in relation to those expected in an ammunition accident. Given that the accident event follows the lines of the exposed stack trials mentioned earlier, upwards of one third of the ammunition involved is likely to explode. Thus, in a magazine that contains 6000 rounds of 105 mm HE shell, there may be 2000 or more explosions. Clearly a process of progressive attrition will gradually break up and weaken the building to the point at which it collapses either totally or in part. Having collapsed there is a likelihood that building materials may be in close proximity to rounds which subsequently explode and may become a source of secondary debris. Alternatively the collapse may "snuff out" the fire and reduce the extent of the event. Clearly a further understanding of the consequences of the initiation of larger quantities of HD 1.2 ammunition is needed in order to propose with confidence reductions in Quantity-Distances or predict fatality probabilities for risk assessment for HD 1.2 storage in structures.

12 The availability of the Spantech igloos at Woomera offered the opportunity to determine the effects of progressive attrition on at least one type of structure. A test program has, therefore been agreed between the Australian and UK ESTC and the US DDESB in which stacks of wooden packaged, TNT and Composition B loaded 105 mm HE shell will be subjected to bonfire testing.

THE TEST PROGRAM

Aim

13 The aim of the trials is to determine the effects, both structural and external to the structure, of the accidental initiation of HD 1.2 explosives when they are housed in a SPANTECH igloo.

Trial Outline

14 Four tests are to be carried out, three in an igloo damaged in the 1990 test and subsequently repaired and one in an undamaged igloo. In each test a stack of M1 105 mm HE ammunition positioned in the igloo will be subjected to the standard UN bonfire test (Reference 15).

Objectives

15 The trial objectives are the measurement of the following:

15.1 The overall sequence of occurrences during the event, ie the time to first reaction, the times and types of reaction (detonation, lower order explosion, propellant burn etc).

15.2 The peak overpressure and impulse (for each explosive/detonative event) as a function of time at defined points in the igloo and outside the door.

15.3 A structural survey of the igloo following each test to determine the damage caused.

15.4 Debris/fragment throw from the igloo. Ideally debris velocity for debris/fragments projected through the doorway should be measured.

15.5 Debris/fragment collection. Position, mass and aspect ratio will be recorded.

15.6 Video records of the event both inside and outside the igloo. For safety reasons it is intended to monitor the conditions in the igloo after the event is desirable.

Igloos

16 The SPANTECH igloo (Figures 1 & 2) is a commercially designed, circular section earth covered structure. The main arch of the building is made from pre-formed corrugated steel sections clipped together and contained between reinforced concrete rear and head walls. After the erection of this steel inner skin, concrete is sprayed over the arch to a thickness of 250mm. The whole structure is then mounded and covered to a minimum depth of 600mm with earth.

17 One igloo was damaged in the 1990 test (Reference 4) It was penetrated by a large piece of concrete from the NATO Standard double bay igloo donor building. Engineers at Woomera advised that "acceptable for trial" repairs would not be expensive; however SPANTECH Pty Ltd, having a natural interest in their product's performance, have offered to repair the building gratis.

18 Doors on the igloos will be removed to allow for the best supply of oxygen to the bonfire and the worst potential fragmentation effects through the opening.

19 A detailed structural survey will be carried out on each igloo before the commencement of the test program to provide a baseline condition for comparison with post-test conditions. After each test, the test ESH will be surveyed to determine the damage caused by the test and whether the ESH is safe and suitable for use for further testing.

Site Preparation

20 The site around the igloos and in particular in front of the doorways will be cleared and graded to provide a flat impact area for debris or fragmentation from the tests. Where the same igloo is used for a further test, all debris from the earlier test will be cleared prior to the next test.

Ammunition

21 Palleted US TNT-loaded and Composition B-loaded M1 105 mm cartridge packaged in wooden boxes (see Figures 3 and 4) will be provided by either The Naval Air Warfare Center, China Lake, USA or the Australian Army for the tests. Each pallet will have 16 wooden boxes each containing two rounds.

Bonfire

22 The bonfire will be of the type described in Reference 15. Air dried pieces of wood will be piled to form a lattice beneath and around the stack of pallets over a width of at least 100 mm. The whole will be drenched with a suitable liquid fuel and the pile will be ignited on two sides simultaneously. Enough fuel will be used to keep the fire burning for at least 30 minutes.

Instrumentation

23 The overpressures both within the igloo and along the line normal to the centre of the doorway will be measured as a function of time. Three gauges will be mounted internally, one on the headwall above the door, one on the rear wall and one on a side wall half way along the igloo. Three external gauges will be mounted at distances of 10 m, 20 m and 30 m in front of the doorway.

24 Thermocouple measurements will be made of the temperature rise in various positions in the stack.

25 The event will be recorded on videotapes. Proposed external high speed video camera positions are shown in Figure 5. The camera on the headwall above the door is to have a vertical field of view covering the first few metres in front of the doorway. A suitably protected video camera will be mounted above the doorway inside the igloo to monitor the development of the event and conditions after the event. A further documentary video recording will be made of the event from a greater range. Still photographs will be taken before and after the event.

Debris/Fragment Search and Assessment

26 A polar search grid centred on the igloo doorway centre will be surveyed in 20 m sectors out to 400 m and 5^{o} increments out to 20^{o} either side of the normal. This area will be searched for debris and fragments.

27 If the other sides or roof of the igloo are ruptured, further search zones will be defined centred on the rupture point and similar searches carried out.

28 All debris and fragmentation collected will be identified, weighed and principal dimensions measured.

Test Plan

29 Four tests are proposed as described in Table 1 below.

Test No	Igloo	No of Pallets	Position of Stack (See Figure 6)	Type of Explosive
1	Damaged	1	A	TNT
2	Damaged	1	B	TNT
3	Damaged	1	C	COMP B
4	Undamaged	8	A	EITHER**

** The explosive for the 8 pallet test will be that which appears to give the most damaging effects in the previous tests.

Test Schedule

30 It is anticipated that the tests will be carried out in 1995.

THE EXPECTED RESULTS

31 Based on the information from the model trial (Reference 7), it is expected that the igloos will remain structurally intact. Scabbing of the internal surfaces is inevitable, but the likelihood of penetration and subsequent ejection of high velocity debris or fragments is small. Debris and/or primary fragments will be ejected through the doorway and it will, therefore, be necessary to quantify hazardous density distributions and hence QDs in that direction. However it is anticipated that, to the side and rear of igloos all hazard distances can be minimal. The question of read-across to other structures can only be considered when the degree and mechanism of damage to the igloo is known.

32 Given that the 105 mm HE shell is likely to cause more damage per explosion than rounds of lesser calibre, there should be little need to carry out further trials against igloos; whatever distances are defined should suffice for all HD 1.2 ammunition. There may be a need to investigate the effects of HD 1.2 events in brick wall/concrete roof buildings with ammunition of differing calibers as existing trials evidence indicates that structural collapse or wall penetration can occur with smaller calibre explosions. Buildings have been identified at a disused UK site at which some testing of this kind may be possible.

CONCLUSION

33 There is an internationally identified requirement for an explosion consequence database to enable more defensible quantity-distance criteria to be set for the storage of Hazard Division 1.2 ammunition. Whilst information has already been gathered on the consequences of the initiation of stacks of HD 1.2 ammunition in the open, little information exists on the influence that containing buildings might have. A program of tests has been defined to determine the effects of the initiation of such ammunition in SPANTECH igloo structures. This program, to be commenced in 1995, is a joint Australia/UK effort with the US contributing by the provision of ammunition and some instrumentation.

FIGURES

1. SPANTECH Schematic Plan and End Elevation

2. The SPANTECH Igloo.

3. M1 105 mm Cartridge Pallet Configuration

4. M1 105 mm Cartridge

5. Camera Positions C1 to C6

6. Proposed Stack Positions in the Igloo

REFERENCES

1. Trials to Determine the Consequences of the Accidental Ignition of Stacks of Hazard Division 1.2 Ammunition; M J Gould, UK ESTC and W D Houchins, NSWC Dahlgren; presented at the 25th DDESB Explosives Safety Seminar, Anaheim CA, August 1992.

2. Trials to Determine the Consequences of the Accidental Ignition of Stacks of Hazard Division 1.2 Ammunition; M J Gould, UK ESTC and W D Houchins, NSWC Dahlgren; presented at PARARI 93, Canberra, Australia, October 1993.

3. Trials to Determine the Consequences of the Accidental Initiation of Stacks of Hazard Division 1.2 Ammunition; M J Gould, UK ESTC and W D Houchins, NSWC Dahlgren; presented at the 26th DDESB Explosives Safety Seminar, Doral Resort, Miami, Florida, August 1994.

4. Proposed Program for the Evaluation of the Hazard from Stacks of Hazard Division 1.2 Ammunition Inside Storage Structures; Michael M Swisdak Jr, NSWC Dahlgren; January 1992.

5. ESTC Report No 1/91; Joint Australian/UK Stack Fragmentation Trials, Phase 4, Test 1; J Henderson; November 1990.

6. Coalesced Defence Trial 6/445 Explosive Storehouse Design Trial and 6/447 Stack Fragmentation Phase 4 for Department of Defence; G Horoschun; Australian Construction Services Civil Engineering Practice/Structural Group Report No 91/S024; 12 April 1992.

7. Assessment of SPANTECH 13m and 23m Explosives Storehouses; Australian Ordnance Council Reporting Proceeding No 207.92; 28 August 1992.

8. NATO AC/258-D258 "Manual on NATO Safety Principles for the Storage of Ammunition and Explosives 1976 [Corrigenda No 22] (Access Limited)

9. Report AC/258-NO(MG)IWP/80; Information on the fire of 14 May 1985 in Norway in a Semi Trailer loaded with 40mm HE-T Ammunition; April 1986.

10. Report AC/258-NO(MG)IWP 80; Information on the fire of 14 May 1985 in Norway in a Semi Trailer loaded with 40mm HE-T Ammunition - Report from an External Stack Fire Test.

11. Explosion Tests in Model Underground Magazines (Part 3) Bonfire Cook-off Test of Ammunition; Nakahar S, Motoba A and Katoh S; Kogyo Kayaku Kyokaishi 1986, vol 47 no 4 (HSE Translation No 12145).

12. Kuroda H; Kogyo Kayaku Kyokaishi Vol 45 1984.

13. Report AC/258-UK(ST)IWP 63; Trial Report - Containment of Small HD 1.2 Detonations; October 1978.

14. Report AR-005-862; The Fragment Containment Characteristics of Explosives Buildings and Other Forms of Fragment Protection for HD 1.1 and HD 1.2 Charges up to 2.5kg TNT Equivalent; R B Crockart and M J Bone; May 1989.

15. United Nations Publication ST/SG/AC.10/11/Rev 1; "Recommendations on the Transport of Dangerous Goods, Tests and Criteria" Second Edition 1990 Test Series 6(c) Page 148 (U).

FIGURE 1 SPANTECH SCHEMATIC PLAN AND END ELEVATION

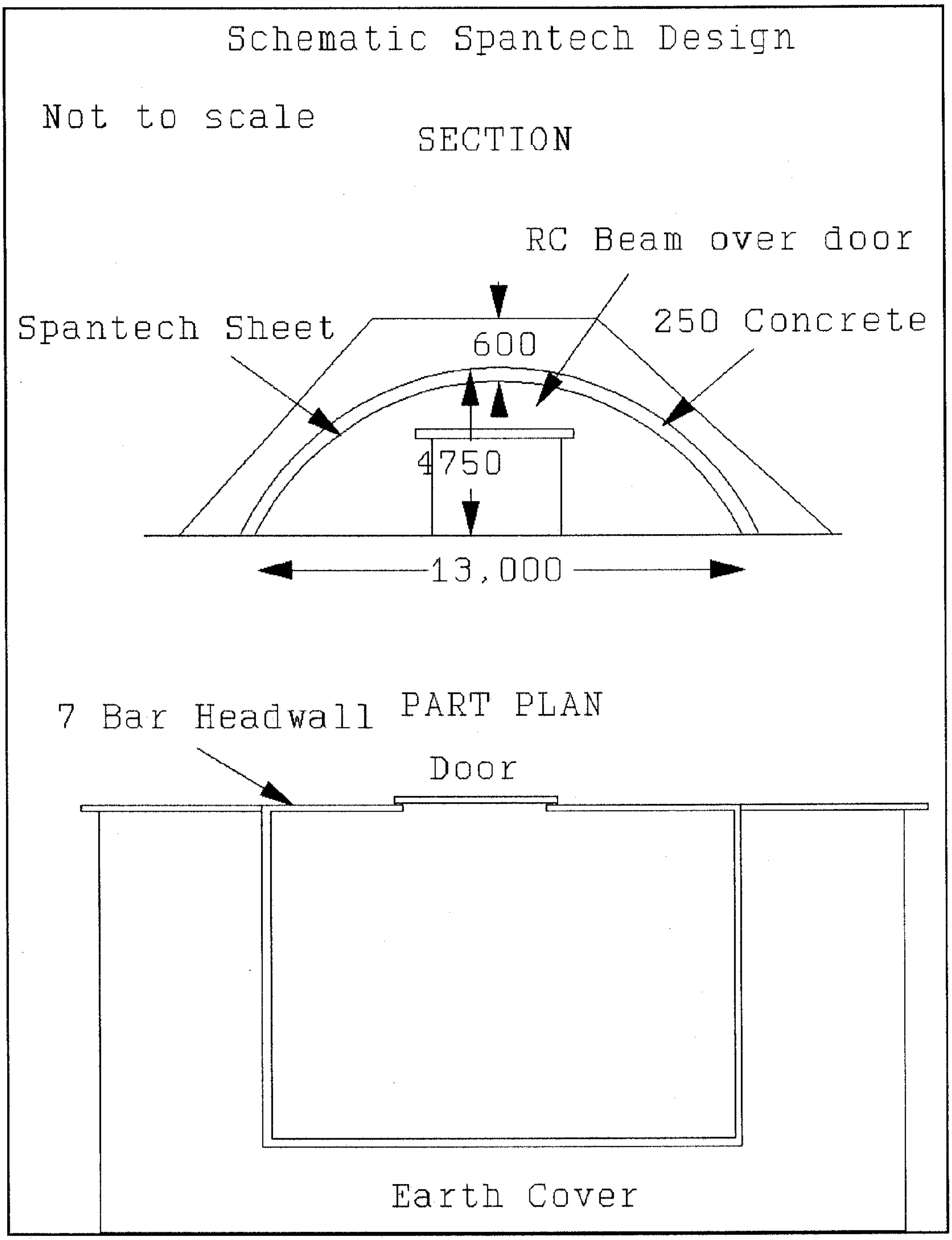


FIGURE 1 SPANTECH SCHEMATIC PLAN AND END ELEVATION

FIGURE 2 THE SPANTECH IGLOO

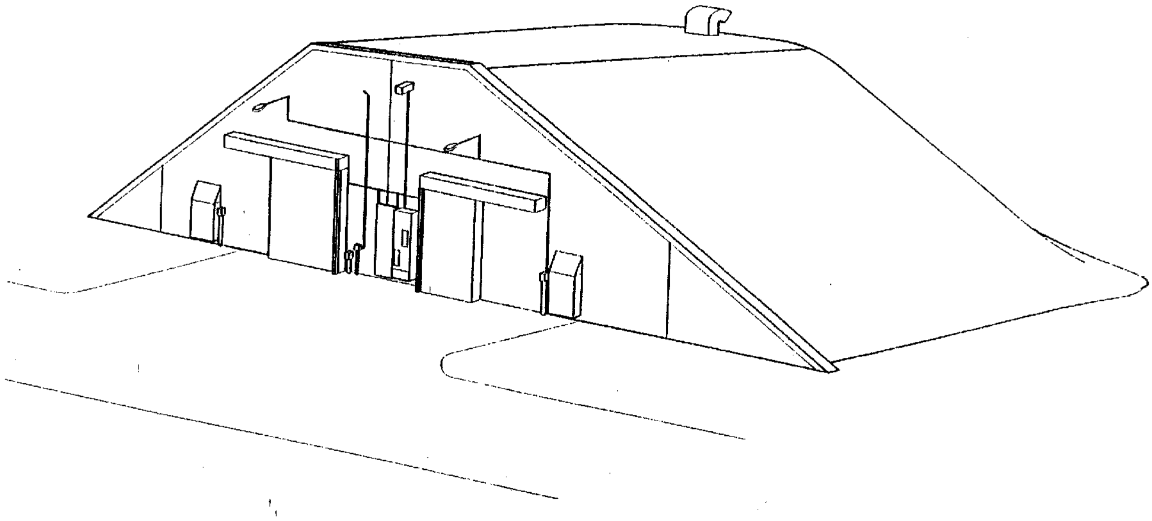
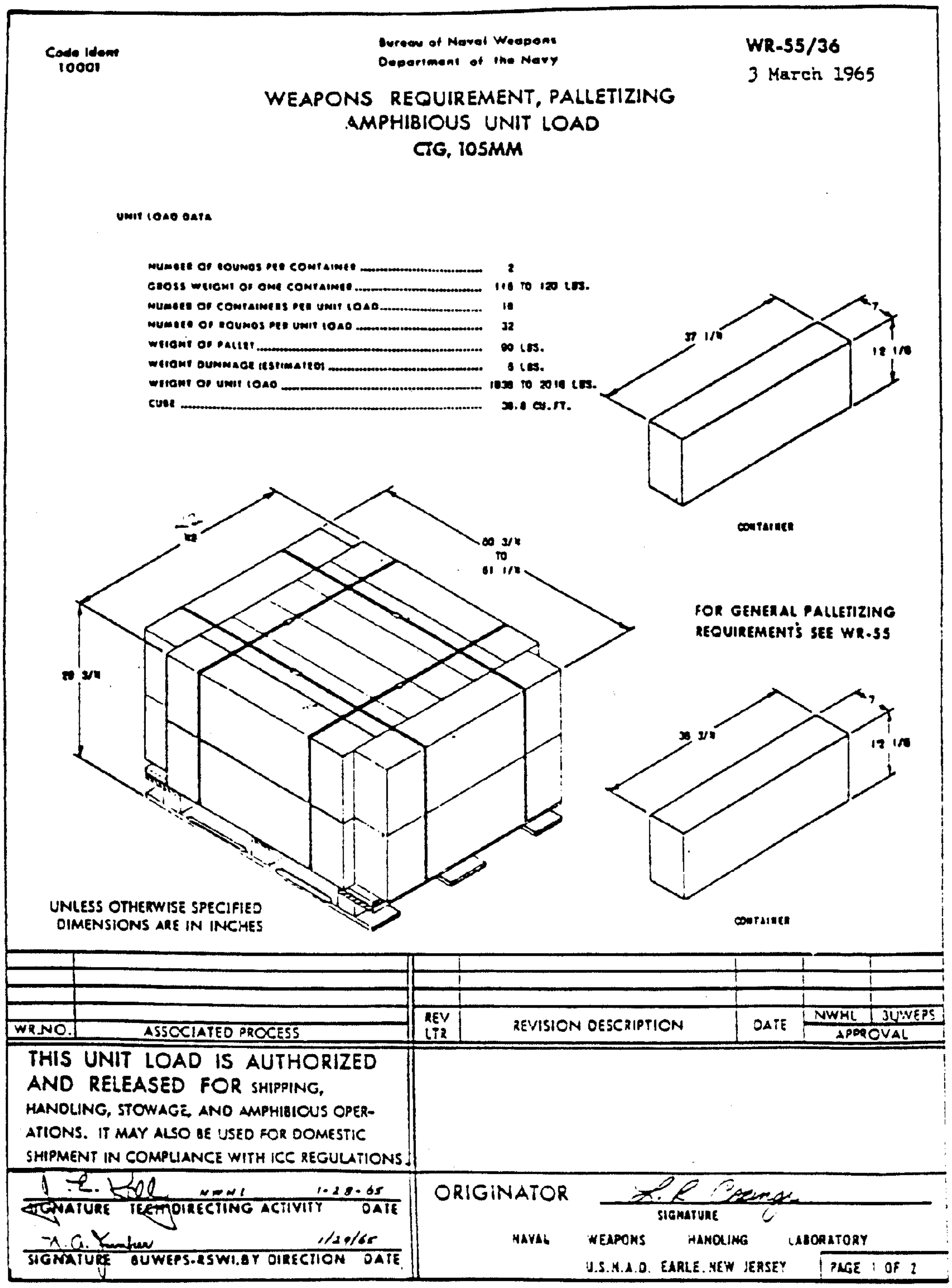


FIGURE 2 THE SPANTECH IGLOO

FIGURE 3 M1 105MM CARTRIDGE PALLET CONFIGURATION



Code Ident
10001

Bureau of Naval Weapons
Department of the Navy

WR-55/36
3 March 1965

WEAPONS REQUIREMENT, PALLETIZING
AMPHIBIOUS UNIT LOAD
CTG, 105MM

UNIT LOAD DATA

NUMBER OF ROUNDS PER CONTAINER	2
GROSS WEIGHT OF ONE CONTAINER	116 TO 120 LBS.
NUMBER OF CONTAINERS PER UNIT LOAD	16
NUMBER OF ROUNDS PER UNIT LOAD	32
WEIGHT OF PALLET	90 LBS.
WEIGHT DUNNAGE (ESTIMATED)	5 LBS.
WEIGHT OF UNIT LOAD	1838 TO 2016 LBS.
CUBE	38.8 CU. FT.

FOR GENERAL PALLETIZING REQUIREMENTS SEE WR-55

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

WR.NO.	ASSOCIATED PROCESS	REV LTR	REVISION DESCRIPTION	DATE	NWHL	BUWEPS
					APPROVAL	

THIS UNIT LOAD IS AUTHORIZED AND RELEASED FOR SHIPPING, HANDLING, STOWAGE, AND AMPHIBIOUS OPERATIONS. IT MAY ALSO BE USED FOR DOMESTIC SHIPMENT IN COMPLIANCE WITH ICC REGULATIONS.

NWHL 1-28-65
SIGNATURE TECH DIRECTING ACTIVITY DATE

1/29/65
SIGNATURE BUWEPS-RSWI.BY DIRECTION DATE

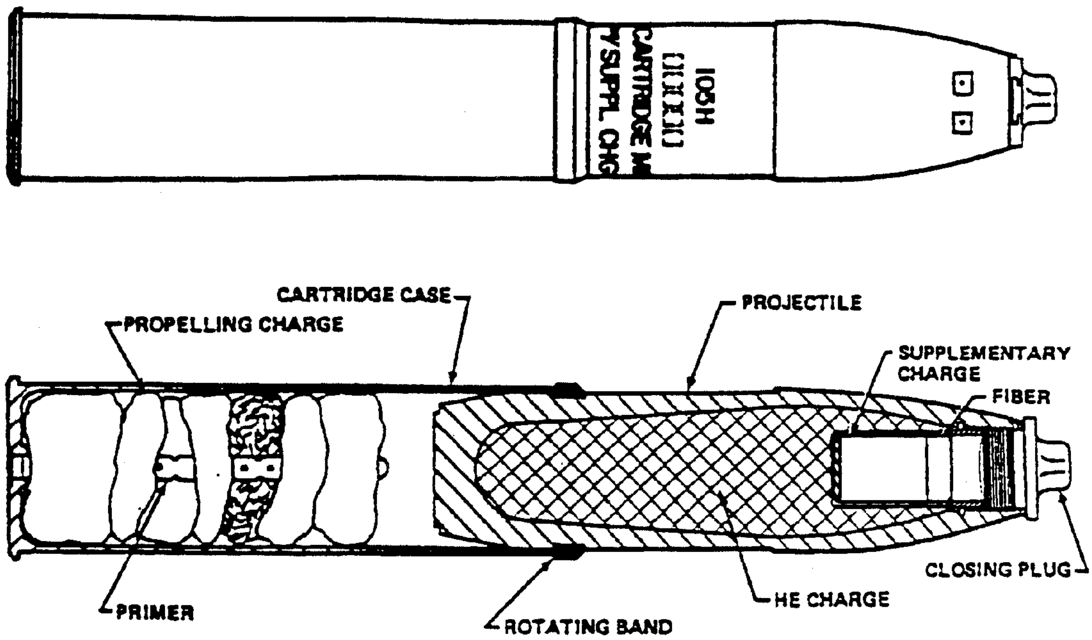
ORIGINATOR
SIGNATURE

NAVAL WEAPONS HANDLING LABORATORY
U.S.N.A.D. EARLE, NEW JERSEY

PAGE 1 OF 2

FIGURE 3 M1 105MM CARTRIDGE PALLET CONFIGURATION

FIGURE 4 M1 105MM CRTRIDGE



<u>Nominal Characteristics</u>

Projectile Body:	Forged Steel
Projectile Body Weight:	25.8 lb
Explosive Fill:	TNT
Explosive Weight:	4.5 lb
Propelling Charge Case:	Spiral Wrap Steel
Propelling Charge Case Weight:	4.7 lb
Propellant:	M1 propellant
Propellant Weight:	2.8 lb

FIGURE 4 M1 105MM CARTRIDGE

FIGURE 5 CAMERA POSITIONS C1 TO C6

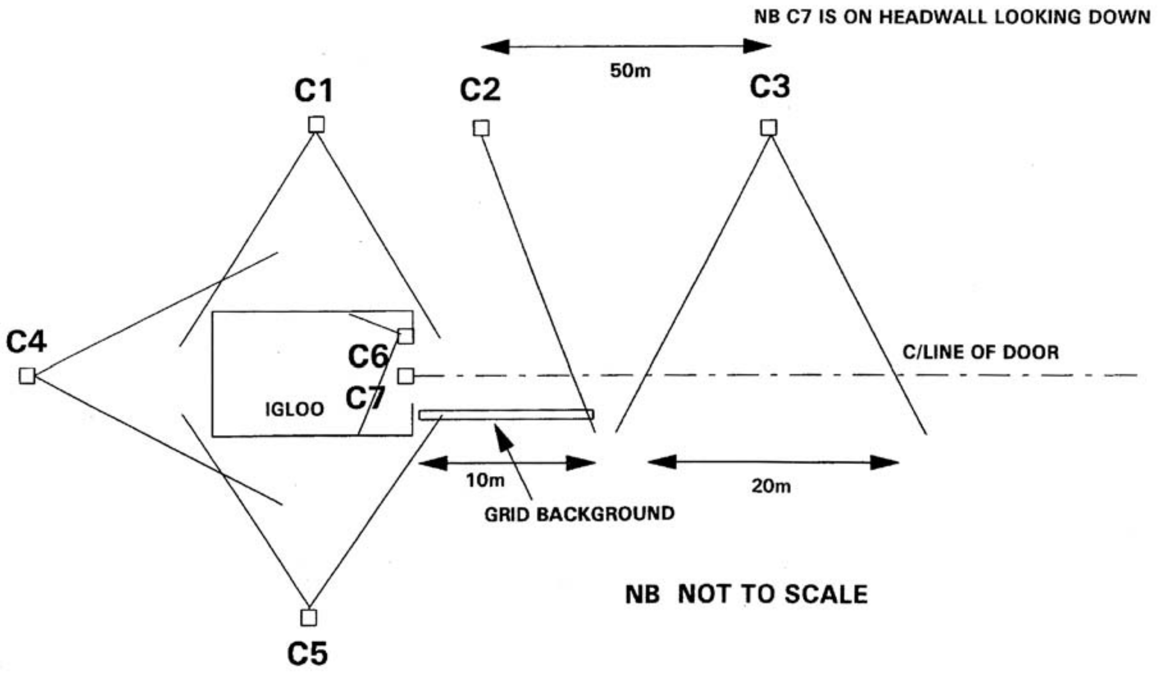


FIGURE 5 CAMERA POSITIONS C1 TO C6

FIGURE 6 PROPOSED STACK POSITIONS IN THE IGLOO

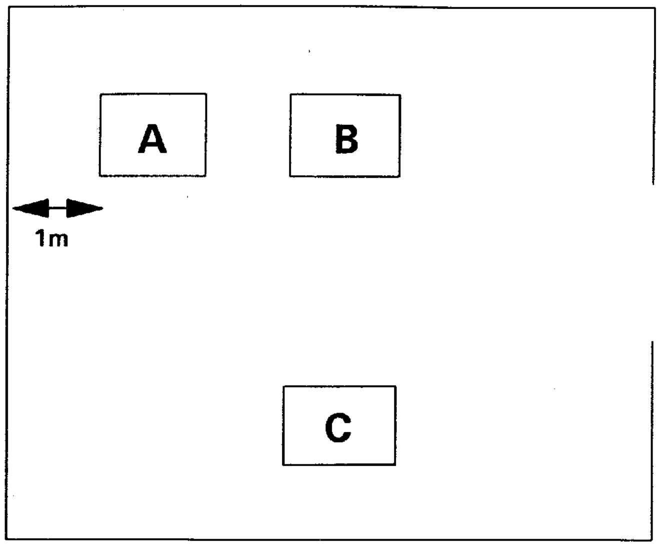


FIGURE 6 PROPOSED STACK POSITIONS IN THE IGLOO